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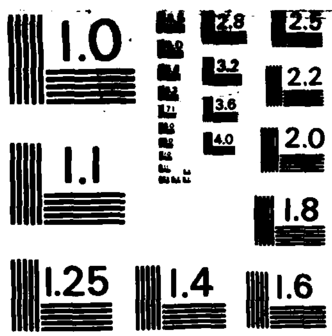

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Interim Scientific Report

MEASUREMENT OF ATMOSPHERIC TRANSMISSION OVER LONG PATHS IN THE INFRARED SPECTRAL REGION

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by

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Instrumentation built for long path spectroradiometric measurements is described. Preliminary results for atmospheric transmission over a 7 km path are reported. A comparison is made with LOWTRAN computations.

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BACKGROUND

For the last several years we have been measuring transmittance in the 2.8-15 micron region in various parts of Israel, using a mobile spectro-radiometric laboratory. In particular, we have paid attention to the contribution of aerosols and water vapor to the absorption in this spectral region. While the LOWTRAN computer code is based mainly on laboratory measurements it was thought that a comparison with field measurements would be appropriate, with special emphasis on reliable determinations of water vapor pressure and aerosols. For this purpose we developed a filter-type radiometer and used it during our field measurements for in situ determinations of water vapor and aerosol content of the atmosphere.

Our plan was to carry out transmittance measurements in areas of high humidity and temperature during 1983 and to turn to the other extreme of low humidity and temperature during 1984. The present report summarizes the results of the first half of the plan.

THE FILTER RADIOMETER

The instrument developed and built for the present study consisted of a parabolic collimating mirror of 20 cm diameter and an f-number of 5. It had a Newtonian mirror of 4.76 cm diameter, mounted at 23.4 cm from the detector. The length of the box in which the radiometer was mounted was 120 cm and its cross section was 30x30 cm. The parabolic mirror could be moved along its axis for focussing the image of the source on the detector.

A special filter wheel was placed in front of the detectors, containing a number of filters, centered at 0.905, 1.06, 2.235, 0.55 and 0.6328 micron, as well as an open aperture for viewing the unobstructed source. A second filter wheel was placed behind the first, with filters centered at 0.39, 1.06, 1.14, 1.243 and 1.591 micron, as well as an open aperture. Behind these two wheels was a detector wheel, containing a Si and PbSe detector (mounted together) and a Ge detector, each with its own preamplifier and power supply.

Aerosol size distribution and concentration were derived using the inversion method developed by our group (see: "Atmospheric aerosols investigated by inversion of experimental transmittance data", E. Trakhovsky, S.G. Lipson and A.D. Devir, Applied Optics 21, 3005-3010 (1982)). The radiometer described above was used for these measurements.

The same radiometer, used with the filters at 1.06 and 1.15 micron, allowed a measurement of the integrated water vapor density along the line of sight. This method was alos developed by our group and described in a paper: "Integrated water vapor density along long atmospheric paths determined by radiometric methods", E. Trakhovsky, A.D. Devir and S.G. Lipson, Infrared Physics 21, 343-348 (1981).

The new radiometer was aligned in the laboratory using a 6328Å laser for checking parallelism and focus. The field of view of the detectors was tested and found to be about 2 to 3 mrad. Uniformity of response across the detector area was found to be very good in the case of Ge and Si, but a roll off of about 10% was found for the PbSe detector. Linearity of response as a function of irradiance was found to be good over 3 orders of magnitude in the range of intensities used in the present experiments. However, direct sunlight entering the radiometer caused saturation of all three detectors. This effect was avoided by placing special baffles and a removable shield around the detectors.

FIELD EXPERIMENTS

Early measurements of transmittance in the 2.5 to 15 micron region were carried out during 1981 in the Dead Sea area. Because of uncertainties in the attendant measurements of humidity and aerosols it was decided to repeat these experiments using the new filter radiometer. A climatic study of Israel revealed that the Dead Sea area, because of its surrounding desert, is actually somewhat drier than the coastal plain of Israel which borders on the Mediterranean Sea. The highest average values of absolute humidity in Israel (about 20 torr of H_2O vapor) are expected during the months of July-August in a stretch of coast between Gaza and Haifa.

It was therefore decided to do a transmittance measurement in the summer of 1983, and a site near Habonim (20 km south of Haifa) was selected.

The Exotech Model 10 Spectroradiometer was placed at distances of 1.02 km and 7.35 km from a blackbody source (kept at 2100°C). The transmittance was measured using the method described by A. Ben-Shalom, D. Cabib, A.D. Devir, D. Goldschmidt, S.G. Lipson and U.P. Oppenheim ("Spectral characteristics of IR transmittance of the atmosphere in the region 2.8-14 microns - preliminary measurements", Infrared Physics 20, 165-174 (1980)).

Several expeditions to this site were undertaken during July 1983. Every time the filter radiometer was placed alongside the Exotech radiometer and the 2100°C blackbody source was viewed by both instruments. The filter radiometer was used for a determination of H_2O content as well as visual range and aerosol size distribution.

A typical example of transmittance measured in the 8-14 micron region is shown in Fig. 1. The upper curve represents the experimental results, while the lower shows the LOWTRAN-4 calculation for the parameters in the upper right hand corner of the Figure. It is seen that the experimental transmittance curve is higher than the calculated curve by a considerable amount. By assuming the LOWTRAN-4 code to be correct for all atmospheric constituents except for the H_2O continuum, it is possible to derive from Fig. 1 new values for $C_s(\lambda)$, the self-broadened attenuation coefficient (and its dependence on wavelength), as well as a new value for the constant γ. This study is now in progress.

Since the highest H_2O pressure attained was only 16.7 torr in the present experiments, another field trip is planned for the summer of 1984. In the winter (February-March 1984) an attempt will be made to measure transmittance for very low H_2O pressures, probably in the Golan Heights. Water vapor pressures of about 5 torr will hopefully be attained.

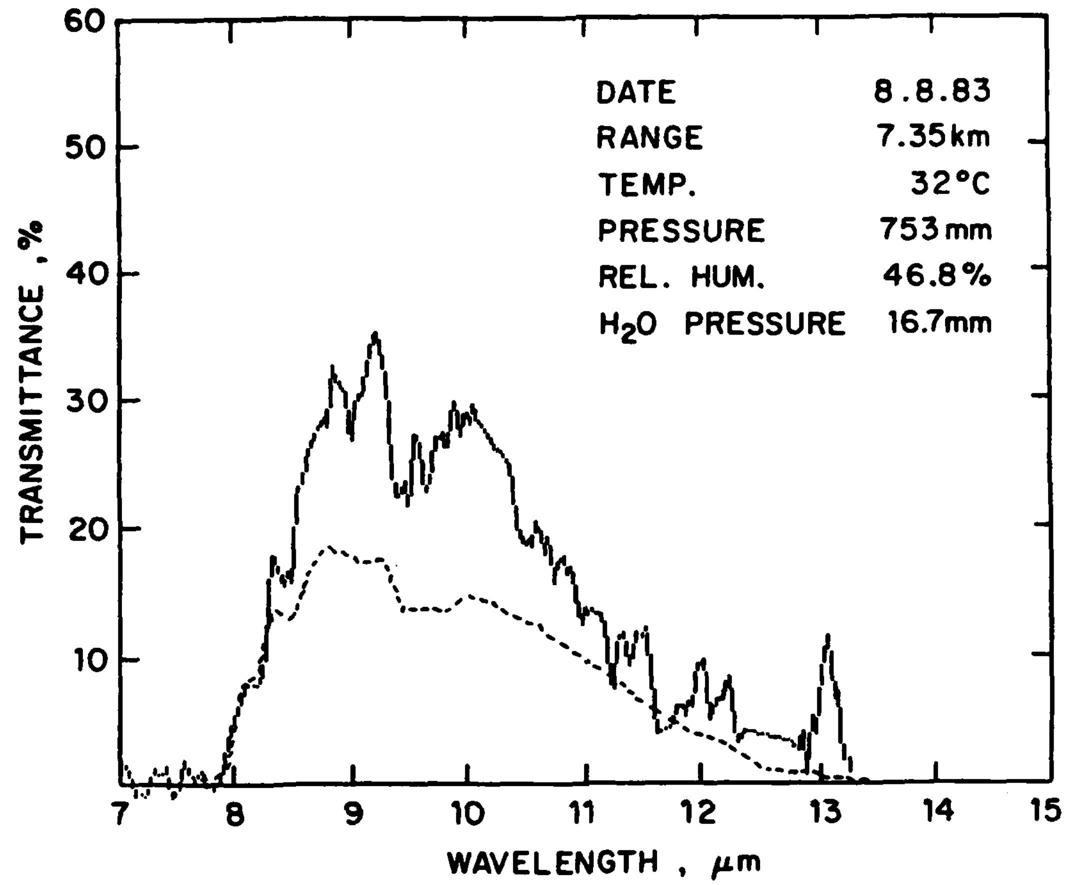

Fig. 1. Atmospheric transmittance measurements (upper curve) compared with LOWTRAN-4 calculation (lower curve) in the 7-14 micron region. Measurement was made in the Habonim area.

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